How are magnets used in electric cars?

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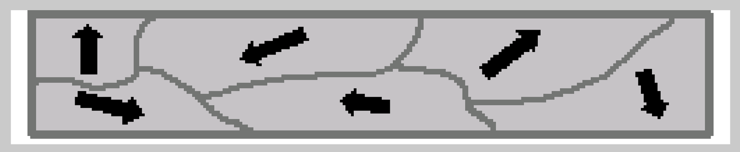
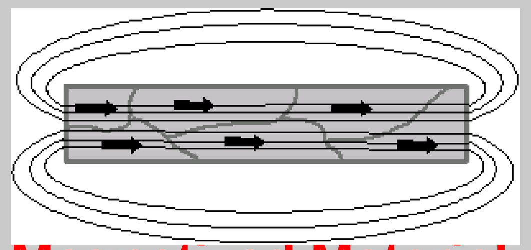
MAGNETS

Magnets are found in headphones, computers, CD players, cars, and many other devices we use on a daily basis. A magnet is any material with the physical property that enables it to attract pieces of iron, nickel, cobalt, and steel. Each magnet has a north and south pole, with magnetic field lines of force that exit the magnet from the north pole and enter its south pole. The more magnetic field lines a magnet has, the more powerful the magnet is. The fundamental law of magnets is that opposites attract and likes repel.

All materials have atoms with magnetic fields. When magnetic fields of many atoms in a certain material are in the same direction as one another, a magnetic domain is formed. If a material is not magnetized, the magnetic domains point in random directions causing the magnetic fields of some domains to cancel the magnetic fields of other domains. If a material is magnetized, most of the magnetic domains are pointing in the same direction.



Unmagnetized Material



Magnetized Material

MAGNETS IN ELECTRIC CARS

Electric drive motors use permanent magnets to convert electrical energy into mechanical energy. Electric drive motors operate on the fundamental law of magnets: the north end of one magnet is attracted to the south end of another magnet and the north end of one magnet will repel the north end of another magnet. Inside an electric drive motor, these attracting and repelling forces create rotational motion, which can provide the car with the energy necessary to move the car.

Most permanent magnets start to lose a lot of their magnetic energy at about 100°C (196°F), which makes them inefficient in electric cars with drive motors that can reach temperatures of about 200°C (392°F). A high-performance permanent magnet composed of neodymium, yttrium, dysprosium, iron, and boron has been designed to operate at 200°C and maintain good magnetic strength.

CURRENT RESEARCH

The $Nd_2Fe_{14}B$ (2-14-1) permanent magnet contains a rare-earth metal component, an iron component, and a boron component. The rare-earth metal component is an alloy of neodymium, dysprosium, and yttrium. When these rare-earth metals are combined, there is much less degradation of the magnetic properties as temperature increases. The iron component contains an iron-cobalt alloy, with high magnetic properties. Cobalt in small amounts is necessary to increase the curie temperature of the magnet. Cobalt is very expensive, so scientists are currently trying to reduce the amount of cobalt present in the 2-14-1 permanent magnet, without reducing the magnetic properties or the curie temperature (the temperature where magnetic domains start to randomize). The boron component forces the rare-earth and iron components into this structure that makes the magnet permanent. Boron makes the magnetic domains more fixed causing them to be less likely to move into random directions, which would reduce magnetic strength.

Scientists are currently using rapid solidification to reduce the size of the grains of the materials, which makes the magnetic domains more difficult to become randomized and reduces the chance for the magnet to become unmagnetized.

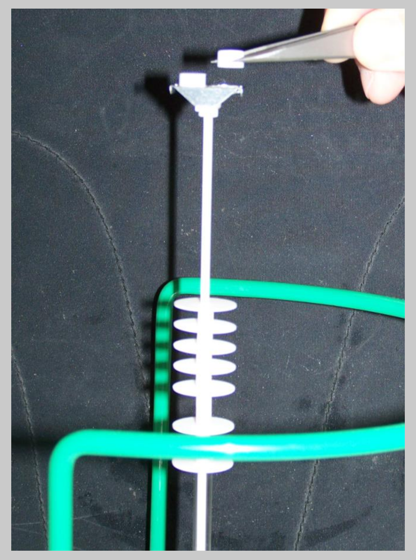
Thermal Properties of Matter

When the sample undergoes changes from a solid to a liquid, melting occurs and heat (energy) flows from the surrounding environment into the solid. This causes the particles of the solid to vibrate faster and the bonds holding the particles together are broken, which allows the liquid particles to flow around each other. This is an endothermic reaction.

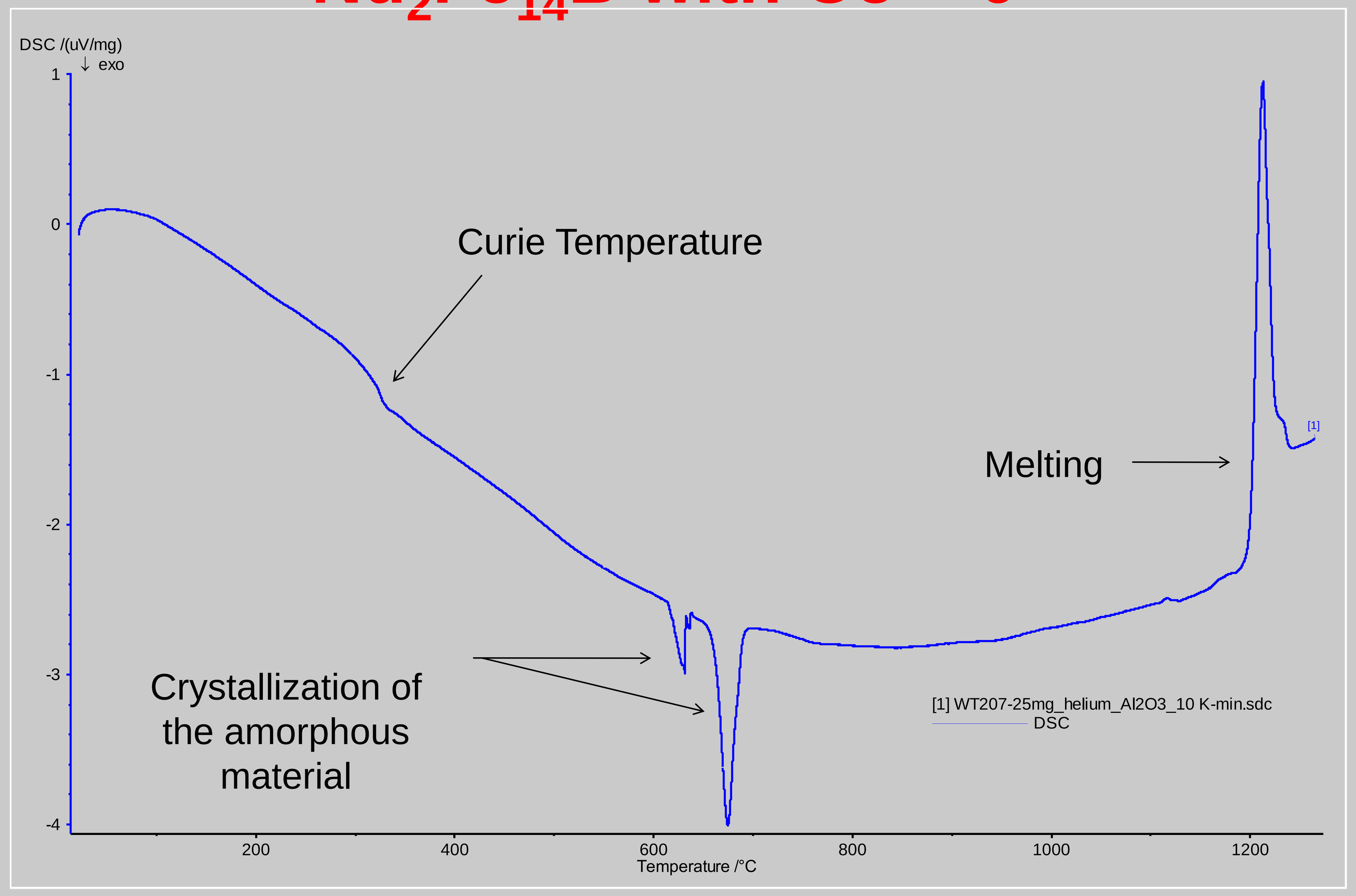
When the sample undergoes changes from a liquid to a solid, freezing occurs and heat (energy) flows from the sample into the surrounding environment. As this happens, the particles move closer together and bonds develop to hold the particles in nearly fixed positions. This is an exothermic reaction.

DIFFERENTIAL SCANNING CALORIMETRY (DSC)

Differential scanning calorimeters (DSC) are machines that study how properties of materials change with temperature. The DSC measures the difference in the amount of heat (energy) required to increase the temperature of a sample (in the front crucible) and an empty reference (the back crucible). Both the sample and reference are maintained at nearly the same temperature throughout the experiment.



$Nd_2Fe_{14}B$ with Co = 0



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